REMARKS

Reconsideration of the application is respectfully requested for the following reasons:

1. Rejection Under 35 USC §112, 2nd Paragraph

This rejection has been addressed by amending claims 1 and 6 to change "the" to –a– or –an– before the first recitation of the listed terms.

It is respectfully noted that similar amendments have been made to claim 10.

Since all of the amendments concern antecedents and/or are formal in nature, and therefore do not change the scope of the claims, entry and consideration of the amendments is respectfully requested.

2. Rejection of Claims 1-4 and 6-8 Under 35 USC §103(a) in view of U.S. Patent No. 6,470,055 (Feher) and the Publication Entitled "*Time-Frequency Well Localized Pulse for Multiple Carrier Transmission*" (Haas)

This rejection is respectfully traversed on the grounds that the Feher patent and Haas publication, whether considered individually or in any *reasonable* combination, fails to disclose or suggest a method in which:

- the time-bandwidth product (TBP) of a symbol is decomposed and expanded; *and*
- the resulting eigensignals are overlaid in both time and frequency domains,
  - such that the respective eigensignals corresponding to the original symbol can be **overlaid in both time and frequency domains** and thereby occupy a **same physical space** (rather than being side-by-side overlapped as in the case for conventional multiplexing methods such as time or frequency division multiplexing).

According to the method of the invention, by decomposing the TBP of a given symbol, and non-linearly expanding the TBP using the "eigensignals" of the symbol (which form an orthogonal signal basis set, the symbols can be overlaid (*i.e.*, combined) so that they occupy the same

physical bandwidth. The invention, in essence, is based on the Inventor's realization that eigensignals resulting from decomposition and expansion of a TBP in fact do form an orthogonal signal basis set that, like the pieces of a puzzle, can be put together or overlaid so as to occupy a minimal amount of bandwidth. **None** of the references applied by the Examiner even remotely suggests a way to obtain constituent signals of a symbol that can be overlaid in both the time and frequency domains, as claimed, much less decomposition and expansion of the TBP of a symbol into "eigensignals" that can be overlaid in the claimed manner.

In contrast, the Feher patent does not address spectrum overlay methods at all. Instead, it is directed to methods involving non-linearly amplified (NLA) power efficient RF systems and bit rate agile (BRA) signal processors, neither of which has anything to do with orthogonal signal spectrum overlay, as claimed.

Similarly, the Haas paper also does not disclose any sort of spectrum overlay methods. Instead, the Haas paper is directed to a single pulse that is said to provide superior multipath performance in multiple carrier transmission with frequency spacing between carriers. While it is true that Haas uses orthogonal wave functions, they are not used for the same purpose or in the same context as those of the claimed invention. Orthogonal wave functions are of course known, but not for the purpose of increasing spectral efficiency by expanding decomposed TBPs into orthogonally overlaid basis sets. In Haas, the orthogonal wavefunctions are used to construct pulses in a multi-carrier system, whereas the claimed spectrum overlay is based on a single carrier and does not use multiple carriers (modulation of the single carrier is actually by amplitude modulation).

Neither the Feher patent nor the Haas paper disclose or suggest the claimed decomposition and expansion of the TBP of a symbol into eigensignals that form an orthogonally overlaid signal basis set. The orthogonal wave functions disclosed in the Haas paper are used to prevent interference between low rate subchannels in a multi-carrier transmission system, and are not the result of expansion of a decomposed TBP. While the pulses of Haas, like all pulses,

have a time-bandwidth product, there is absolutely no suggestion in Haas of decomposing the TBP, much less of expanding the decomposed TBP into overlaid eigensignals. *Instead, Haas discloses a product of a* ***polynomial*** *and a* ***Gaussian pulse,***[1] *which is not the same as TBP, which is the product of* ***signal duration*** *and* ***signal bandwidth***. Furthermore, there is no suggestion that the orthogonal wave functions of Haas could possibly be used in connection with the transmission systems disclosed in the Feher patent.

On page 4 of the Official Action, the Examiner alleges that the Haas publication states that "the product is achieved orthogonally through an ambiguity function of H(t)" (page 9 line 3-5). The examiner is incorrect. What is stated in Haas is that "To achieve orthogonality, we evaluate the ambiguity function of H(t)." What is meant here is that these authors are seeking superior multipath performance for a pulse, H(t). The ambiguity function, a well-known function originating in radar, provides cross-correlations whereby retention of orthogonality - a gauge of superior multipath - can be assessed. The claimed invention, on the other hand, does not address multipath, nor does it address the use of orthogonal signals to construct a single pulse.

Turning to claim 2, the Examiner states that "*in combination Feher and Haas et al. teaches the method recited in claim 1, wherein the number of orthogonal signals obtained in a specific symbol is set by the size of the TBP of the symbol.*" In reply, the Applicant respectfully submits that the Feher patent and Haas publication, whether considered individually or in any reasonable combination, include no such teaching. Page 8, paragraph 7 of the Haas publication, cited in the Official Action, states that the duration and bandwidth of an envelope function in the multi-carrier system should be close to those of a Gaussian pulse and that the envelope should be orthogonal in the time and frequency domains and normalized, which is not at all the same as relating the number of orthogonal signals resulting from decomposition of the TBP to the size

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[1] In fact, it was French mathematician, Charles Hermite (1822-1901), not Haas, who first wrote down a function that is "a product derived from a polynomial and a Gaussian pulse," at a time when communication of symbols through pulse transmission had not even been conceived, and there was no way to control either pulse duration or bandwidth.

of the TBP, or of overlaying such signals. Haas merely provides limits for the TBP, and says nothing about its decomposition.

In addition, the Examiner states that "*Therefore it would have been obvious to one having ordinary skill in the art at the time of the invention was made to have a OFDM signals (col. 13, line 33) as taught by Feher orthogonal and normalized signals as taught by Haas et al. To reduce intersymbol interference.*" This statement evidences a misunderstanding of the present invention, which has nothing to do with reducing **intersymbol interference** since the orthogonal signals of the invention are not side-by-side symbols that might interfere with each other, but rather the result of decomposition and expansion of the TBPs of respective symbols. In fact, the original specification very clearly and specifically distinguishes the claimed spectral overlay of subchannels from "orthogonal frequency division multiplexing" (OFDM) in which the subchannels are laid side-by-side in the frequency domain, as illustrated in Fig. 2 of the present application:

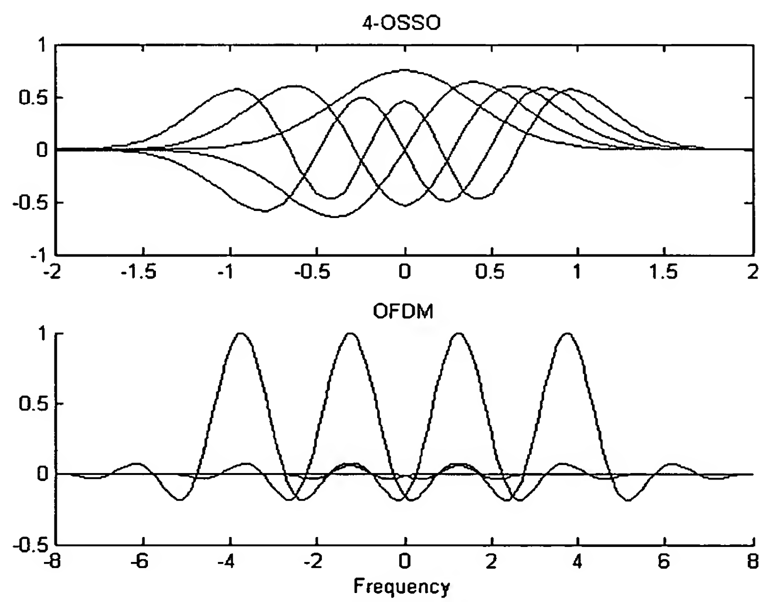

Fig 2 Top: the envelope of an OSSO symbol composed of four WH signals – hence 4-OSSO represented in both the time and frequency domains. Bottom: an Orthogonal Frequency Division Multiplexing (OFDM) symbol in the frequency domain. In the case of OSSO, signal orthogonality is a due to zero cross-correlation of the WH signals. In the case of OFDM, signal orthogonality is due to the displacement of the frequency content of each signal in the frequency domain.

This figure taken from the Applicant's original drawings clearly shows the difference between OFDM referred to by the Examiner in the Official Action and the spectral overlay of the claimed invention.

With respect to claim 3, which is actually rejected because the Haas publication discloses "*a multicarrier modulation technique in whereby splitting up the large bandwidth occupied by a high symbol rate into a low rate subchannels with small bandwidth,*" it is again respectfully noted that the claimed invention is <u>not</u> a multicarrier modulation technique but rather utilizes one single carrier. While Haas does disclose Hermite orthogonal functions, it does so in order to construct a single pulse with superior multipath, not to overlay those signals to achieve superior bandwidth efficiency.

With respect to claim 4, while Feher and Haas "disclose a multiplexer" as noted by the Examiner, the claims are not directed to a multiplexer per se, but rather a multiplexer used in connection with the eigensignal overlay of claim 1, which is not taught by either of the applied references.

With respect to claim 6, it is respectfully noted that the adaptive antenna arrays taught by Feher and mentioned in the Official Action are not crucial to or required by the claimed invention, and that the equalizers required are not adaptive Feher equalizers. Furthermore, it is again noted that the Hermite equation is not used for the same purpose in the claimed invention as in Haas. While the Hermite equation of French mathematician, Charles Hermite (1822-1901) has been known for more than a century, the present invention is a specific application of the equation which is not even remotely suggested by the Haas publication.

Because the Feher and Haas references do not disclose any sort of spectral overlay, much less forming an orthogonally <u>overlaid</u> signal basis set by decomposing and expanding the TBP of a given symbol, and because of additional features recited in each of the remaining claims,

withdrawal of the rejection of each of claims 1-4 and 6-8 under 35 USC §103(a) is accordingly respectfully requested.

3. Rejections of Claims 5, 6, and 9 Under 35 USC §103(a) in view of U.S. Patent No. 6,470,055 (Feher) and the Publications Entitled "*Time-Frequency Well Localized Pulse for Multiple Carrier Transmission*" (Haas) and "*COFDM: An Overview*" (Zou)

These rejections are respectfully traversed on the grounds that the Zou publication, like the Feher patent and Haas publication, whether considered individually or in any *reasonable* combination, fails to disclose or suggest a method in which the time-bandwidth product (**TBP**) of a symbol is **decomposed and expanded** and the resulting eigensignals are overlaid in both time and frequency domains such that the respective eigensignals corresponding to the original symbol can be **overlaid in both time and frequency domains** and thereby occupy a **same physical space** (rather than being side-by-side overlapped as in the case for conventional multiplexing methods such as time or frequency division multiplexing). Instead, the Zou publication is directed to a frequency division multiplexing system, the differences between frequency division multiplexing and the claimed signal overlay being clearly illustrated in Fig. 2 of the present application, reproduced above.

It is noted that the symbol-representing waveforms of the claimed invention, which are formed by orthogonally overlaid eigensignals, can themselves be frequency division multiplexed. However, the invention itself is not directed to frequency division multiplexing, sub-band coding, or any sort of side-by-side overlapping of constituent signals, as taught by the Zou publication. The signals that are frequency division multiplexed according to the method described in the Zou publication are not made up of overlaid eigensignals resulting from decomposition and expansion of a TBP, and therefore the Zou publication does not make up for the deficiencies of the Feher patent and Haas publication. Withdrawal of the rejection of claims 5 and 6 under 35 USC §103(a) is therefore respectfully requested.

4. Comments on U.S. Patent No. 5,640,423 (Archer)

The Archer patent, which was not applied in the Official Action, is the only reference that discloses spectrally efficient **orthogonal modulation** that, like the claimed invention, is **not multicarrier**. However, the method and system disclosed in this patent differs from those of the claimed invention in a number of respects (in addition to those noted in the Preliminary Amendment submitted on December 13, 2007):

(1) Looking at Figs 2 and 3 of the Archer patent, there seem to be only one bank of correlators, not two banks in I and Q. The Archer approach also modulates in phase and amplitude, apparently not realizing that modulating in phase would result in a decline in symbol rate and hence efficiency, and also destroy orthogonality.

(2) In the Archer approach, there is no symbol overlap. Instead, there is an entirely linear relation: $T_a = NT_e$. In the claimed overlapped approach, to use Archer's nomenclature: $T_a < NT_e$ and the relationship is nonlinear. The claimed approach is, contrary to Archer's claims, the only one that results in superior bandwidth efficiency.

(3) In the Archer approach, there are linear equalizers (305a & 305b) but no cancellers. Linear equalization results in noise amplification, and therefore not advisable. The "OSSO" approach uses nonlinear and noncausal equalizers and cancellers.

Difference (2) is an especially significant difference. The linear relation means that if there are six signals in parallel with the Archer symbol, then in the same duration of the Archer symbol, six QAM symbols can be transmitted. In other words, if N signals are in parallel in the Archer symbol, then in the same duration (T_a) of the Archer symbol, N QAM symbols of duration T_e can be transmitted. As a result, Archer's modulation is actually no more efficient than conventional QAM. Why go to the trouble of changing to Archer modulation, if the same bandwidth efficiency is obtained as the already existing QAM? In comparison, according to the claimed invention, N signals in parallel in a symbol may be transmitted in a period T_a which is less than the total duration NT_e for transmitting an equal number of QAM symbols. This means that a superior bandwidth efficiency is obtained for the claimed transmission versus QAM. Furthermore, although not mentioned in the patent application, the symbol overlap employed by

the claimed invention, *i.e.*, the induced intersymbol interference ISI and interchannel interference ICI (which have to be removed on reception by nonlinear equalizers) result in an even greater bandwidth efficiency with respect to QAM than is possible with the method and system disclosed in the Archer patent.

Having thus overcome each of the rejections made in the Official Action, withdrawal of the rejections and expedited passage of the application to issue is requested.

Respectfully submitted,

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